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NEW ALLOY FOR FIVE-CENT COINS

Observant people may have noticed recently a slight change in the color of new 5-cent coins. The fact is that the familiar "nickel" no longer contains nickel. As in many other cases, the use of nickel in coinage has had to give way to more urgent military needs.

The request of the War Production Board not to use nickel in "nickels" met with a sympathetic response from Hon. Nellie Tayloe Ross, Director of the Mint. But the proposed change was far from easy to carry out. Many requirements had to be met. The new 5-cent coin had to resemble closely the old one in color and appearance and freedom from tarnish. The new alloy had to be hard enough to resist wear and at the same time take clean-cut impressions from the Mint dies. The bullion value of the new alloy had to be less than the actual value of the coins, otherwise the new coins might be melted up and used for other purposes. Finally, the new coins had to work properly in coin vending machines.

This last requirement proved to be troublesome, and the Bureau of the Mint and the War Production Board requested the cooperation of the National Bureau of Standards in finding a solution. Vending machines are protected by various devices so that they cannot be operated with slugs. Consequently, it was necessary in the new alloy to match within limits the electrical conductivity, the magnetic permeability, the resilience, and the weight of the old "nickel."

The Bureau at once proceeded with the preparation of samples of an alloy of equal weights of silver and copper, as well as of similar alloys containing small percentages of silicon, manganese, etc. Each alloy was prepared as an ingot, or slab, portions of which were converted into specimens for chemical analysis, determination of electrical resistance, and other properties. Sample coin-selector mechanisms were obtained from eight manufacturers and their normal performance was determined by repeated use of 200 bona-fide "nickels" until each mechanism had been subjected to 2,000 tests. Two mechanisms were chosen for tests on "slugs" made of new alloys—one because of its superior selectivity, the other because it was typical of units in actual use.

Although the Bureau of the Mint would have preferred a simple, binary alloy, such as copper-silver, the tests immediately showed that such coins

[1] Published with approval of the Director of the Budget.

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would invariably be rejected by vending machines because of low electrical resistance. Experiments were then made with small percentages of alloying elements such as phosphorus, silicon, and aluminum, which are known to raise the resistivity of copper. While the first two increased the resistivity of the silver-copper alloy slightly, they made the alloy hard, brittle, and unworkable. Small additions of aluminum did not have much effect on resistivity, but they lowered the density and improved the working qualities, besides making the coins somewhat more resistant to tarnish.

Electrolytic manganese in various amounts was then tried, and it was found that when the percentage of manganese reached a little over 6, the alloy first showed definite signs of being acceptable in the machines. Further increases in manganese, up to 10.5 percent, progressively increased the resistivity and improved the acceptance. The alloy containing 45 percent of silver, 45 percent of copper, and 10 percent of electrolytic manganese, therefore, appeared promising. Although the cold-rolled sheet was slightly harder than a similar sheet of copper-nickel (91 as compared to 85 on the Rockwell B scale), this did not appreciably affect the workability in laboratory experiments, a fact confirmed at the Bureau of the Mint, where the 10-percent-manganese alloy was rolled, stamped, and minted in an experimental run. Except that somewhat higher pressure was required in rolling and minting, the making of these coins followed conventional procedure. Tests of the minted coins in the vending machines confirmed the evidence obtained from smooth slugs, i. e., that the 10-percent alloy is about as acceptable as the present nickel.

Manganese lowered the density of the silver-copper alloy from 9.52 to 8.97 grams per cubic centimeter, but the latter figure is near enough to the value of the copper-nickel (8.77) to have permitted coins made of the new alloy to be kept to the customary weight of 5 grams per coin by a slight reduction in thickness of the planchet, and without changing the diameter. Moreover, the addition of manganese alters the golden or brassy color of the silver-copper alloy to something approaching the appearance of the copper-nickel alloy, though a slightly yellow tinge remains. A surface film of silver, produced by pickling in nitric or sulfuric acid after hot-work or annealing treatments, was believed to be too soft to result in any permanent improvement in appearance or in resistance to tarnish.

The silver-copper-manganese alloys were all inferior to copper-nickel in the matter of tarnish. When the slugs were handled repeatedly in making the machine tests, they became discolored with a dark greenish film which came off on the fingers. This might not be serious on coins in active use or where the cloth lining of pockets or receptacles would tend to remove the tarnish, but apparently it can not be eliminated.

A few four-component alloys were prepared to study the effect on the silver-copper-manganese alloy of the presence of another alloying element or metallic impurity. It was found that the addition of 2.6 percent of aluminum raised the resistivity from about 25 to 32 and produced an alloy that had a perfect record of acceptance in the machines. The density is closer to the regular nickel alloy and the workability seemed to be improved. The quaternary alloy is somewhat harder than the ternary alloy but it is tougher and stood up better under rolling. For all these reasons, an alloy containing about 7.5 percent of manganese and 2.5 percent of aluminum appeared to be preferable to the 10-percent-manganese alloy. Virgin aluminum would not have been necessary; aluminum-copper and certain grades of scrap could have been used.

When the Bureau started the investigation it was understood that electrolytic manganese in amounts sufficient to meet the needs of the coinage would be available. Later, the War Production Board advised that it might be necessary to substitute nonelectrolytic manganese in whole or in part for the electrolytic product. Alloys were consequently prepared by adding ferromanganese to 8- and 9-percent-manganese alloys to observe the effect of increasing the iron content above the usual 0.04 percent which is present in the alloys made from electrolytic manganese. The presence of 0.35 percent or more of iron renders the silver-copper-manganese alloys ferromagnetic and these were, therefore, rejected by the machines. However, 0.15 percent of iron was found to be permissible, but to obtain this low value would require a low-iron manganese.

Finally, a change in the silver situation made it necessary to lower the silver content of the alloy because, otherwise, the 5-cent coin might actually have been worth more than this as metal. An alloy of 56 percent copper, 35 per-

cent silver, and 9 percent manganese was selected by the Bureau of the Mint as a reasonable compromise, and this is now being used in coining 5-cent pieces. As a result, it is estimated that an additional 300 tons of nickel will be available annually for the production of war materials.

THERMAL EXPANSION OF TITANIUM

In the Journal of Research for February (RP1520) Peter Hidnert gives the linear thermal expansion of titanium (97.2 percent) at various temperatures between —190° and +700° C. The coefficient or rate of expansion of titanium increases from about 5×10^{-6}/° C at —150° C to about 12×10^{-6}/° C at 650° C. The data on thermal expansion do not confirm the conclusion by Koenigsberger and Schilling concerning polymorphic transformations of titanium at about 310° and 590° C, based on determinations of electric resistance. The results of the present investigation are in agreement with Schulze's conclusion in regard to the absence of these transformations, which is also based on resistance measurements.

EFFECT OF ALTITUDE ON KNOCK RATING

Following the work described in Technical News Bulletin 302 (June 1942), altitude-chamber tests were made at air pressures from sea level to 8,000 feet and higher on two variable compression engines. These were adjusted in each case to give standard knock on fuels of from 40 to 100 octane number. The results were analyzed to determine the effect of altitude on octane number requirement. According to a paper by Donald B. Brooks before the winter meeting of the Society of Automotive Engineers in Detroit on January 14, the resulting relations are nearly identical for the two engines and are in good agreement with road tests, indicating that the effect of altitude may be expected to be about the same for all engines.

REVISED HANDBOOK ON WEIGHING AND MEASURING DEVICES

Revised specifications, tolerances, and regulations for commercial weighing and measuring devices are set forth in the Bureau's Handbook H29, which has just been released.

This revised edition incorporates all changes adopted by the National Conference on Weights and Measures and recommended for promulgation by the States, since the publication of H22 in February 1938; in other words, H29 is the same as a completely annotated copy of H22.

In providing for subsequent revisions, the new Handbook is arranged on a different plan from the old one. Instead of attaching all correction sheets to stubs at the back of the book, two or three blank pages are inserted after each of the several codes of specifications, and on these pages any corrections can be pasted, thus grouping related material and making the book handier to use.

The publication of H29 is of particular interest at this time because certain of the recommendations of the National Conference on containers, scales, etc., are being incorporated in various Limitation Orders of the War Production Board. The price is 60 cents a copy; orders should be sent to the Superintendent of Documents, Government Printing Office, Washington, D. C. The Handbook is bound in buckram.

MINIATURE GEIGER-MÜLLER COUNTER

New uses for Geiger-Müller counters, one of the most sensitive devices known for measuring radiation, have been made possible by the development of counters of a size comparable to a hypodermic needle. As described in the February Journal of Research (RP1525), L. F. Curtiss has succeeded in making counters about 1½ inches long and only 1/32 inch in diameter. In spite of their small size, they operate satisfactorily and are at least as sensitive per unit area as the larger counters customarily used. The individual pulses from these tiny counters are, surprisingly enough, much larger than those from larger counters.

These miniature counters are particularly useful in locating and measuring narrow beams of radiation, such as the beam of X-rays reflected from a crystal. They can also be used in the study of biological specimens by means of radioactive tracers. In such applications the radioactive substance is introduced in small amounts into the living organism and its subsequent distribution is studied. By using "hypodermic needle" counters this study could be made without destroying the living organism, and since the counter could be introduced directly into the tissue, the sensitivity of the measurement would be greatly increased.

A MODIFIED CARIUS COMBUSTION TUBE

A difficulty which limits the usefulness of the Carius method for determining halogens and sulfur in organic substances is the frequent breakage of the tubes during the decomposition with fuming nitric acid. Observations made by C. L. Gordon at the Bureau appear to explain these failures, and in the Journal of Research for February (RP1521) he suggests a simple modification that will obviate most of them.

The familiar Carius tubes of Pyrex glass can not be properly sealed in the laboratory. Residual strains in the glass seals cause the tubes to burst at pressures much lower than those to be expected from the normal strength of the glass. By sealing smaller neck-tubes on the usual heavy-walled tubes, all the seals except the small final seal can be oven-annealed at the factory. It is recommended that all seals be well rounded, and that before annealing, the tube surface be flamed to eliminate minute scratches. The tubes thus made should be individually wrapped to prevent scratching of the finished surface while they are stored before use.

The bursting pressure of the unmodified tubes, sealed without special attention to annealing, was found to be between 1,000 and 1,400 lb/in.^{2} The pressures developed in the Carius procedure by 8 grams of fuming nitric acid in a total volume of 100 milliliters at 200° and 300° C were found to be 500 and 1,520 lb/in^2, respectively. The modified tubes did not burst until a pressure of over 2,500 lb/in^2 was reached; this is sufficiently above the expected pressures to recommend the use of the modified tubes in place of those now offered.

ANALYTICAL SEPARATIONS BY CONTROLLED HYDROLYTIC PRECIPITATION

The advantages of controlled alkalinity in hydrolytic precipitations do not appear to have been fully realized, nor have its possibilities for effecting separations been sufficiently exploited. Experience at the Bureau in developing analytical procedures for the platinum metals and for dental gold alloys has shown the utility of hydroxide precipitation, made under conditions of controlled alkalinity. This is easily accomplished with the aid of indicators, of which many are available today. A definite end point may be established with buffers or by merely neutralizing the solution with such reagents as sodium hydroxide, sodium carbonate, or sodium bicarbonate. The direct addition of indicator to the solution is not always feasible, but a simple, convenient, and reliable method of determining an end point is to test a drop of the solution which clings to the stirring rod with a drop of a 0.01-percent solution of an indicator.

To ascertain the completeness of precipitation of hydroxides under conditions of controlled alkalinity in the range pH 1 to 10, Raleigh Gilchrist has made experiments with over forty individual elements. As reported in the February Journal of Research (RP1519), he found that the hydroxides of many of the metals were quantitatively precipitated within a rather narrow range of alkalinity. No attempt was made to follow the hydrolytic curves to locate the precise pH at which minimum solubility existed. Rather, the experiments were of an empirical nature, and the precipitations were made at definite alkalinities, dependent on the indicators available. The observations on the individual elements were gathered largely in connection with problems arising in the analysis of platiniferous materials.

The main purpose of the paper is to direct the analyst's attention to the alkalinity conditions that permit the quantitative hydrolytic precipitation of many of the metallic elements, and to point out how the hydrolytic method can be utilized in effecting chemical separations; it is not the intention to outline the separation of each pair of elements.

The advantages of hydrolytic precipitation are illustrated by a few familiar separations. For instance, the separation of copper from arsenic by polysulfide is not sharp; some copper sulfide tends to dissolve. Complete separation of these two elements, however, is readily accomplished by precipitating the copper as its hydroxide in a boiling solution at an alkalinity of pH 10. At this same alkalinity, copper is likewise separated from selenium and tellurium. Quadrivalent tin in hydrochloric acid solution can be separated from copper without using polysulfide, if the tin is hydrolytically precipitated at pH 1.5.

In slightly acid solution tervalent chromium is readily oxidized to chromate in the presence of sodium bromate, and, by adjusting the alkalinity of the solution to the appropriate end point, cobalt, nickel, manganese, titanium, aluminum, indium, zinc, copper, lead, etc., can be precipitated and thus separated from chromium.

The separation of lead from elements which form oxyacids is interesting. Lead is quantitatively precipitated by the chromate ion in the range pH 6.3 to 8. Under the influence of sodium bromate, lead chromate is decomposed when the alkalinity of the solution exceeds pH 7, and hydrated lead dioxide is precipitated. In like manner, lead sulfate, which is appreciably soluble, is very easily decomposed, with the complete precipitation of hydrated lead dioxide. Similar separations of lead from selenate, tellurate, and rsenate take place.

Preliminary experiments indicated that the oxidation of lead and the production of lead dioxide resulted when lead phosphate, lead vanadate, and lead molybdate were treated with sodium bromate.

Elements which form oxyacids apparently are not separated from other elements with equal ease. Arsenic, selenium, and tellurium, in their highest states of valency, are readily separated from copper, for example, at an alkalinity of pH 10, without the addition of bromate. Vanadium, however, does not seem to be as easily separated; at least at alkalinities less than pH 10. Operation at a higher alkalinity might be more effective, but the work on vanadium was not carried sufficiently far to ascertain the necessary conditions.

The hydrolytic precipitation of copper and zinc from mercury is an interesting possibility. No precipitation occurs in solutions of mercuric salts, which are not too concentrated, until the alkalinity greatly exceeds pH 10. Experiments showed that zinc hydroxide and copper hydroxide, precipitated at pH 10, were not contaminated by mercury.

Controlled hydrolytic precipitation has proved valuable in developing analytical procedures for materials which contain the precious metals. By converting the four platinum metals (palladium, rhodium, iridium, and platinum) into their nitrito-complexes, these four metals may be separated from other elements by adjusting the alkalinity of the solution to that at which the particular element precipitates quantitatively. Many of the base-metal hydroxides can be collectively precipitated. Hydrolytic precipitation in the presence of sodium bromate furnishes the only accurate means of separating rhodium and iridium from platinum. Hydrolytic precipitation also makes possible the recovery of osmium, ruthenium, and iridium for determination. It is likewise valuable in isolating elements from solutions in which a considerable quantity of alkali salts have accumulated.

pH VALUES OF PHOSPHATE SOLUTIONS

A paper (RP1524) by Roger G. Bates and S. F. Acree in the February Journal of Research reports a series of acidity values for a number of solutions of phosphates which may be used to improve the measurement of acidity and to facilitate its control. The measurement and control of acidity and alkalinity, as explained in TNB305 (September 1942), is of almost universal importance in industrial processes which are carried out in solutions.

This control is dependent upon accurate methods of determining acidity, or pH. The Bureau has in progress the selection and purification of substances suitable as pH standards, and is determining their values at a number of temperatures. These compounds can be used for the calibration of measuring equipment and for the regulation of acidity in the research laboratory, factory, or wherever the problem of pH control arises.

It has long been recognized that one of the most useful standards for determining pH in the region of acidity close to that of water is a mixture of primary and secondary phosphate salts. A study of 42 phosphate mixtures at 13 temperatures between 0° and 60° C by electromotive-force methods has now been completed. The second dissociation constant of phosphoric acid and related thermodynamic quantities have been evaluated, and pH values have been assigned to each of the phosphate solutions for any temperature between 0° and 60° C.

COMBINATION OF WOOL WITH WEAK ACIDS

Wool is often exposed during processing to solutions containing weak acids, certain of which have long been known to have profound effects on the swelling and the elastic properties of the fibers. Nevertheless, practically all studies of the chemistry of the reaction of wool with acids have been made with strong acids, i. e., those which are totally dissociated into their constituent ions. RP1523 (February Journal of Research) by research associates of the Textile Foundation supplies some of the missing information.

It is shown that wool combines with undissociated molecules of weak acids as well as with their ions. Because of the high concentrations of weak acids which are present in solutions of low pH values, more weak acid may be

combined by wool in the undissociated form than in the ionic form. The total amount of some of these weak acids which may be removed from solution by wool may far exceed the amounts of common strong acids which may be combined. The relative tendencies of the 13 weak acids investigated to combine with wool in the undissociated form vary over a three-hundredfold range. The effect of a variation of temperature on this kind of combination with wool is shown to be very small; because of this, it is suggested that the combination is a solvation of the wool molecules, the weak acids displacing water, which is always found combined with wool when moisture is present. If this is true, the combination of undissociated acids with wool is a result of their hydroxylic properties rather than their acidic characteristics.

MEASURING THE DEGREE OF CURL OF PAPER

The tendency of paper to curl is a source of annoyance in handling, particularly in feeding sheets through automatic machinery in printing and other conversion processes. The causes of curling are various. It may result from a strain in the sheet acquired during manufacture, which suddenly asserts itself when pressure in the package is released. Frequently, however, curling is the result of some maladjustment arising from exposure to moisture in the atmosphere, or drying, which makes one part of the sheet expand or contract more than another part.

Curling is promoted particularly by a difference in expansion or contraction of the two surfaces, resulting from conditions of exposure, nature of the surfaces, or a combination of both. Simple laboratory tests may aid in choosing remedial measures; a common test is to note the maximum amount of curl resulting when a small piece of paper is floated on water. A study of this test has recently been made by Frederick T. Carson and Vernon Worthington at the Bureau with a view toward its improvement and in the hope of learning more about its value and significance.

Several modifications of the flotation apparatus and method were devised in an effort to evaluate curliness in terms of maximum curvature. In RP1522 in the February number of the Journal of Research data are given to show how curliness determined with the curl sizing tester agrees with that determined by an optical method. Good correlation of curliness was found with density, expansivity, sheet shrinkage during fabrication, and air permeability. The results of measurements of curl are in reasonably good agreement with what is known about the behavior in use of the papers studied.

WATER PERMEABILITY OF WALLS

Building Materials and Structures Report BMS94, recently released, gives the results of water-permeability measurements made by Cyrus C. Fishburn on small stucco- and gunite-faced walls and on walls built of "Knap concrete units", before and after outdoor weathering. Six kinds of stucco facings, 2 thicknesses of gunite facings, and 7 kinds of units were represented in a group of 26 walls.

All the stucco- and gunite-faced walls were highly resistant to water penetration. Periods of outdoor exposure at Washington, D. C., varying from 16 to 49 months, had no important effect on permeability. The resistance to penetration of walls built of "Knap concrete units" was excellent after the walls were painted. Photographs showing the appearance of eight typical specimens add to the value of the presentation.

Copies of BMS94 are obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 10 cents each.

NEW AND REVISED PUBLICATIONS ISSUED DURING JANUARY 1943

Journal of Research [2]

Journal of Research of the National Bureau of Standards, volume 30, number 1 (RP1513 to RP1518, inclusive). Price 30 cents. Annual subscription, 12 issues, $3.50.

Research Papers [2]

[Reprints from the October and November 1942 Journal of Research]

RP1499. Heat of combustion of benzoic acid, with special reference to the standardization of bomb calorimeters. Ralph S. Jessup. Price 10 cents.

[2] Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington, D. C. Subscription to Technical News Bulletin, 50 cents a year; Journal of Research, $3.50 a year (to addresses in the United States and its possessions and to countries extending the franking privilege; other countries 70 cents and $4.50, respectively.

RP1505. Wear testing of carpets. Herbert F. Schiefer. Price 20 cents.

RP1506. Chemically modified wools of enhanced stability. Walton B. Geiger, F. F. Kobayashi, and Milton Harris. Price 10 cents.

RP1507. Measurement of densities of synthetic rubbers. Lawrence A. Wood, Norman Bekkedahl, and Frank L. Roth. Price 5 cents.

Circulars [2]

C441. Elevator wire rope maintenance. Price 5 cents.

Handbooks [2]

H29. Specifications, tolerances, and regulations for commercial weighing and measuring devices. (Supersedes H22.) Price 60 cents.

Commercial Standards [2]

CS103-42. Cotton and rayon velour (jacquard and plain) Price 5 cents.

Building Materials and Structures Reports [2]

[Persons who wish to be notified of new publications in the Building Materials and Structures series as soon as they are available should write to the Superintendent of Documents, Government Printing Office, Washington, D. C., asking that their names be placed on the special mailing list maintained by him for this purpose.]

BMS94. Water permeability and weathering resistance of stucco-faced, gunite-faced, and "Knap Concrete-Unit" walls. Cyrus C. Fishburn, Price 10 cents.

Technical News Bulletin [2]

Technical News Bulletin 309, January 1943. Price 5 cents. Annual subscription, 50 cents.

[2] See footnote on page 14.

MIMEOGRAPHED MATERIAL

Letter Circulars

[Letter Circulars are prepared to answer specific inquiries addressed to the National Bureau of Standards and are sent only on request to persons having a definite need for the information. The Bureau cannot undertake to supply lists or complete sets of Letter Circulars or send copies automatically as issued.]

LC711. Thermostat setting and economy in house heating. (Supersedes LC694.)

LC712. Plastics: A short list of selected publications.

RECENT ARTICLES BY MEMBERS OF THE BUREAU'S STAFF PUBLISHED IN OUTSIDE JOURNALS [3]

Change in potential of silver-silver chloride electrodes with time. E. R. Smith and J. K. Taylor. J. Am. Chem, Soc. (1155 16th St., NW., Washington, D. C.) 64, 3053 (December 1942).

Buckling of rectangular plates with built-in edges. Samuel Levy. J. Applied Mechanics (29 West 39th St., New York, N. Y.) 9, No. 4, A–171 (December 1942).

Chemically modified wools of enhanced stability. Walton B. Geiger, F. F. Kobayashi, and Milton Harris. Ind. Eng. Chem. (1155 16th St., NW., Washington, D. C.) 34, 1398 (November 1942).

Effects of superheating, pouring temperature and microstructure on the elastic properties of some plain and alloy cast irons. A. I. Krynitsky and C. M. Saeger, Jr. Trans. Am. Foundrymen's Assn. (222 West Adams St., Chicago, Ill.) 50, No. 2 (December 1942).

[3] These publications are not obtainable from the Government. Requests should be sent direct to the publishers.

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